

**Battelle Team  
Dose Reconstruction  
Project for NIOSH**

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## **International Minerals and Chemical Corporation**

### **BH.1 Introduction**

This document serves as an appendix to Battelle-TBD-6001, Site Profiles for Atomic Weapons Employers that Refined Uranium and Thorium Metals. This appendix describes the results of document research specific to this site. Where specific information is lacking, research into similar facilities described in the body of this Site Profile is used.

### **BH.2 Site Description**

The International Minerals and Chemical Corporation located in Mulberry, Florida was involved in research and development efforts related to the production of uranium from phosphate feed materials for the Atomic Energy Commission (AEC) during the first half of the 1950's. During the last half of that decade, it operated a production unit at its Bonnie Chemical Plant site that produced uranium from monocalcium phosphate and phosphoric acid feed materials. The total production quantity for the five years of operation at the Bonnie location was 100 tons.

#### **BH.2.1 Site Activities**

##### *Research and Development*

International Minerals and Chemical Corporation's (IMC) first contract with the AEC began April 26, 1951. The contract called for the operation of a pilot plant to perform R&D and experimental investigations to recover uranium from phosphate matrix and matrix overburden material from a portion of the Florida pebble phosphate field. The source for the uranium was also described as the leached zone or Bartow clay. (RefID16363)

The pilot plant continued to operate through the end of June 1955. The processes developed there were utilized for the design and construction of a uranium recovery unit at IMC's Bonnie Chemical Plant.

##### *Manufacturing*

IMC's second contract with AEC was for the design and construction of a uranium recovery unit at the Bonnie Chemical Plant. This contract began in July 1952 and ended on May 31, 1955. On June 6, 1955 IMC's third contract with the AEC, which was for the operation of the uranium recovery unit, began. The plant recovered uranium from monocalcium phosphate and phosphoric acid feed materials. The uranium was recovered as green salt (UF<sub>4</sub>) and uranium oxide (U<sub>3</sub>O<sub>8</sub>). The product was shipped to the Feed Materials Production Center in Fernald, Ohio for further processing. (RefID10822, p.12)

This last contract ended in June of 1960 but the plant closed at the end of December 1959 prior to the end of the contract. The production volume during the five years of operation was two to three tons per month. The total production quantity over the full operating period was 100 tons.

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According to plant employees, the AEC completed an inspection of the plant at the completion of operations. No records of the inspection remain. All equipment was removed from the site by IMC in 1962 and sold for salvage value. IMC demolished all the buildings except the main process building. The remaining building and property were transferred to Central Farmers (now CF Industries) early in 1969. CF Industries demolished the old process building in 1976.

### **BH.2.2 Job Categories**

Each claim will be evaluated to determine the most appropriate Job Category from the list below.

REFINING – Uranium Recovery from Phosphate Feed Materials

Plant Floor High	(Involved directly in operations—dose based on Generic Refining TBD)
Plant Floor Low	(Involved in support of operations—dose based on 50% of plant floor high above)
Supervisor	(Assumed to spend some time in the production areas—dose based on 10% of plant floor high above)
Clerk	(Assumed to have minimal exposure—dose based on exposure to 2.5% of plant floor high above)
Employed after AWE period	Assumed to have exposure based upon FUSRAP surveys.

### **BH.3 Occupational Medical Dose**

No information regarding occupational medical dose specific to International Mineral and Chemical was found. Information to be used in dose reconstructions for which no specific information is available is provided in ORAUT-OTIB-0006, the dose reconstruction project technical information bulletin covering diagnostic x-ray procedures.

### **BH.4 Occupational Internal Dose**

No air monitoring data were available. Internal dose calculations are based upon the Generic Refining TBD Scrap Recovery Process.

These values were used to derive the inhalation values presented in Table BH.1. The values in the table present these values as a pCi per calendar day inhalation. These values were used to determine an ingestion intake in accordance with this TBD. Those values are presented as a pCi per calendar day ingestion in Table BH.2

### **BH.5 Occupational External Dose**

No data were found in the Site Research database related to occupational external dose during AEC work. External dose calculations are based upon the Generic Refining TBD Scrap Recovery Process.

Tables BH.4 and BH.5 present these values as mrem per calendar day values to be used for each calendar year listed.

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## BH.6 Residual Contamination

In 1977, Oak Ridge National Laboratory performed a preliminary radiation survey at the IMC site. All that remained to be surveyed was a concrete pad and areas adjacent to the pad. Gamma ray exposure rate measurements were made at 1 m above the surface and beta-gamma dose rate readings taken at 1 cm from the surface. The maximum direct gamma ray exposure measured on the pad was 10-15  $\mu\text{R/hr}$  and the corresponding beta-gamma dose rate was 0.1 mR/hr. The maximum reading found in the area adjacent to the pad was 100  $\mu\text{R/hr}$  at 1 m. The beta-gamma dose rate reading at this location was 0.2 mrad/hr. Background for areas around the plant site was 40 to 45  $\mu\text{R/hr}$ .

Soil and debris samples were also collected and analyzed for the presence of  $^{238}\text{U}$ ,  $^{137}\text{Cs}$ ,  $^{226}\text{Ra}$ . The maximum results were 39, 2, and 28 pCi/g respectively.

The conclusion from the survey was that even though the gamma-ray exposure rates found in the vicinity of the former uranium recovery plant were significantly higher than natural background for this part of Florida, such elevated rates were common at phosphate product plants now in operation. On the basis of this preliminary survey, and historical information, DOE concluded that the residual contamination at the site was not attributable to the AEC-sponsored operations. The site is not included in FUSRAP.

Since the facility where the uranium recovery operations were conducted had already been demolished, the radiological conditions after the completion of AEC contract work could not be assessed. The ORNL preliminary survey data are not representative of residues from the uranium recovery operations so these data have not been used in dose estimates.

It is concluded that there is a potential for significant residual contamination outside of the period in which weapons-related production occurred, from 1962 to 1976. The DOE Worker's Advocacy site lists the residual time period as 1962 to 1977 which has been used in the dose calculations<sup>1</sup>. An estimate of this exposure has been derived from the Generic Refining TBD, using estimates of settled dust and direct alpha levels as described in Chapter 6.0 of the Refining TBD (Battelle-TBD-6001)<sup>3</sup>.

## BH.7 References

1. DOE Office of Health, Safety and Security, EEOICPA web site.  
<http://www.hss.energy.gov/healthsafety/fwsp/advocacy/faclist/findfacility.cfm>
2. Report on Residual Radioactive and Beryllium Contamination at Atomic Weapons Employer Facilities and Beryllium Vender Facilities.  
<http://www.cdc.gov/niosh/ocas/pdfs/tbd/rescon/rcontam1206.pdf> &  
<http://www.cdc.gov/niosh/ocas/pdfs/tbd/rescon/appen-a2.pdf>
3. RJ Traub. 2006. Site Profiles for Atomic Weapons Employers that Refined Uranium and Thorium. Battelle-TIB-6001, Battelle Pacific Northwest Division. Richland, WA.

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**Table BH.1 INTERNAL DOSE PATHWAYS - Inhalation of Airborne Radionuclides**

**Assumptions:**

Pilot Plant Operation April '51 to July '52; design and build plant July '52 to May '55; plant operation June '55 to June '60.

Use data from Battelle-TBD-6001 for scrap recovery operations

Conversion Factor: 2.22 dpm/pCi

Breathing Rate: 1.2 m<sup>3</sup>/hour

All intakes and doses assume full-time employment for the given year.

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Plant Floor High	4/'51-6/'52	Pilot	1000	U234	1.22E+03	5.0	Scrap Recovery Furnace Operator Trays prior to 1952 (TBD-6001)
Plant Floor Low	4/'51-6/'52	Pilot	1000	U234	6.09E+02	5.0	50% of Plant Floor High
Supervisor	4/'51-6/'52	Pilot	1000	U234	3.04E+02	5.0	25% of Plant Floor High
Clerical	4/'51-6/'52	Pilot	1000	U234	3.04E+01	5.0	10% of Supervisor
Plant Floor High	7/'52-5/'55	Design	2000	U234	2.24E+02	5.0	Resuspension TBD-6001 Section 8.5.2
Plant Floor Low	7/'52-5/'55	Design	2000	U234	1.12E+02	5.0	Resuspension TBD-6001 Section 8.5.2
Supervisor	7/'52-5/'55	Design	2000	U234	5.60E+01	5.0	Resuspension TBD-6001 Section 8.5.2
Clerical	7/'52-5/'55	Design	2000	U234	5.60E+00	5.0	Resuspension TBD-6001 Section 8.5.2
Plant Floor High	6/'55-12/'60	Operation	2000	U234	8.12E+02	5.0	Scrap Recovery Furnace Operator Calciner post 1952 (TBD-6001)
Plant Floor Low	6/'55-12/'60	Operation	2000	U234	4.06E+02	5.0	50% of Plant Floor High
Supervisor	6/'55-12/'60	Operation	2000	U234	2.03E+02	5.0	25% of Plant Floor High
Clerical	6/'55-12/'60	Operation	2000	U234	2.03E+01	5.0	10% of Supervisor
Plant Floor High	1/'61-12/'76	Residual	2000	U234	1.35E+02	5.0	Table 6.4 TBD-6001
Plant Floor Low	1/'61-12/'76	Residual	2000	U234	6.74E+01	5.0	Table 6.4 TBD-6001
Supervisor	1/'61-12/'76	Residual	2000	U234	1.69E+01	5.0	Table 6.4 TBD-6001
Clerical	1/'61-12/'76	Residual	2000	U234	1.69E+00	5.0	Table 6.4 TBD-6001

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**Table BH.2 INTERNAL DOSE PATHWAYS - Ingestion of Airborne Radionuclides**

**Assumptions:**

Air Concentration to Intake Conversion Factor:  $3.06E-05 (M^3/d)/(hr/y)$  - see 7.1.6 TBD-6000

Deposition velocity: 0.00075 m/s

Resuspension Factor:  $1.00E-06 1/m$

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Plant Floor High	4/'51-6/'52	Pilot	1000	U234	$1.13E+01$	5.0	Scrap Recovery Furnace Operator Trays prior to 1952 (TBD-6001)
Plant Floor Low	4/'51-6/'52	Pilot	1000	U234	$5.67E+00$	5.0	50% of Plant Floor High
Supervisor	4/'51-6/'52	Pilot	1000	U234	$2.83E+00$	5.0	25% of Plant Floor High
Clerical	4/'51-6/'52	Pilot	1000	U234	$2.83E-01$	5.0	10% of Supervisor
Plant Floor High	7/'52-5/'55	Design	2000	U234	$2.09E+00$	5.0	Resuspension TBD-6001 Section 8.5.2
Plant Floor Low	7/'52-5/'55	Design	2000	U234	$1.04E+00$	5.0	Resuspension TBD-6001 Section 8.5.2
Supervisor	7/'52-5/'55	Design	2000	U234	$5.22E-01$	5.0	Resuspension TBD-6001 Section 8.5.2
Clerical	7/'52-5/'55	Design	2000	U234	$5.22E-02$	5.0	Resuspension TBD-6001 Section 8.5.2
Plant Floor High	6/'55-12/'60	Operation	2000	U234	$7.56E+00$	5.0	Scrap Recovery Furnace Operator Calciner post 1952 (TBD-6001)
Plant Floor Low	6/'55-12/'60	Operation	2000	U234	$3.78E+00$	5.0	50% of Plant Floor High
Supervisor	6/'55-12/'60	Operation	2000	U234	$1.89E+00$	5.0	25% of Plant Floor High
Clerical	6/'55-12/'60	Operation	2000	U234	$1.89E-01$	5.0	10% of Supervisor
Plant Floor High	1/'61-12/'76	Residual	2000	U234	$1.26E+00$	5.0	Table 6.4 TBD-6001
Plant Floor Low	1/'61-12/'76	Residual	2000	U234	$6.28E-01$	5.0	Table 6.4 TBD-6001
Supervisor	1/'61-12/'76	Residual	2000	U234	$1.57E-01$	5.0	Table 6.4 TBD-6001
Clerical	1/'61-12/'76	Residual	2000	U234	$1.57E-02$	5.0	Table 6.4 TBD-6001

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**Table BH.3 EXTERNAL DOSE PATHWAYS - Whole Body**

**Assumptions:**

Submersion Dose Conversion Factor: 2.462E-09 mrem/h/dpm/m<sup>3</sup>

Deposition velocity: 0.00075 m/s

Contaminated Surface Dose Conversion Factor: 5.615E-10 mrem/h/dpm/m<sup>2</sup>

All work categories receive the same direct exposure rate from scrap.

Variation between work categories is based on dose rates from contamination and suspended material.

Design and Residual periods: Assume no handling of U - only exposure is from residual contamination on floor and in air

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	External Whole Body (mR/d)	GSD	TBD Reference or Research Justification
Plant Floor High	4/'51-6/'52	Pilot	1000	U234	2.89E+01	5	Scrap Recovery Furnace Operator Trays prior to 1952 (TBD-6001)
Plant Floor Low	4/'51-6/'52	Pilot	1000	U234	1.75E+01	5	50% of Plant Floor High
Supervisor	4/'51-6/'52	Pilot	1000	U234	1.19E+01	5	25% of Plant Floor High
Clerical	4/'51-6/'52	Pilot	1000	U234	6.73E+00	5	10% of Supervisor
Plant Floor High	7/'52-5/'55	Design	2000	U234	2.07E+01	5	Resuspension TBD-6001 Section 8.5.2
Plant Floor Low	7/'52-5/'55	Design	2000	U234	1.65E+01	5	Resuspension TBD-6001 Section 8.5.2
Supervisor	7/'52-5/'55	Design	2000	U234	1.44E+01	5	Resuspension TBD-6001 Section 8.5.2
Clerical	7/'52-5/'55	Design	2000	U234	1.25E+01	5	Resuspension TBD-6001 Section 8.5.2
Plant Floor High	6/'55-12/'60	Operation	2000	U234	4.27E+01	5	Scrap Recovery Furnace Operator Calciner post 1952 (TBD-6001)
Plant Floor Low	6/'55-12/'60	Operation	2000	U234	2.75E+01	5	50% of Plant Floor High
Supervisor	6/'55-12/'60	Operation	2000	U234	1.99E+01	5	25% of Plant Floor High
Clerical	6/'55-12/'60	Operation	2000	U234	1.31E+01	5	10% of Supervisor
Plant Floor High	1/'61-12/'76	Residual	2000	U234	1.74E+01	5	Table 6.4 TBD-6001
Plant Floor Low	1/'61-12/'76	Residual	2000	U234	1.49E+01	5	Table 6.4 TBD-6001
Supervisor	1/'61-12/'76	Residual	2000	U234	1.30E+01	5	Table 6.4 TBD-6001
Clerical	1/'61-12/'76	Residual	2000	U234	1.24E+01	5	Table 6.4 TBD-6001

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**Table BH.4 EXTERNAL DOSE PATHWAYS - Skin**

**Assumptions:**

All assumptions from TBD-6001 Section 6.3

Operational Period: Non-penetrating dose to skin 9.0 mR/hour (hands and forearms) 2.65 mR/hour (other)

Plant Floor High: Assume hands in contact with material 50% of time. Other skin is 100% of dose rate at 1-ft, 20.8 mrem/h

Plant Floor Low: 50% of Plant Floor High

Supervisor: assume 10% of Plant Floor Low for time in contact with material

Clerical: assume no handling of U.

Residual Period: 1962 - 1976

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Hands & Forearms (mR/d)	Other Skin (mR/d)	GSD	TBD Reference or Research Justification
Plant Floor High	4/51-6/52	Pilot	1000	U234	2.55E+03	2.28E+02	5	Scrap Recovery Furnace Operator Trays prior to 1952 (TBD-6001)
Plant Floor Low	4/51-6/52	Pilot	1000	U234	1.28E+03	1.14E+02	5	50% of Plant Floor High
Supervisor	4/51-6/52	Pilot	1000	U234	1.28E+02	2.28E+01	5	25% of Plant Floor High
Clerical	4/51-6/52	Pilot	1000	U234	0.00E+00	0.00E+00	5	10% of Supervisor
Plant Floor High	7/52-5/55	Design	2000	U234	1.73E-03	5.48E-01	5	Resuspension TBD-6001 Section 8.5.2Residual Contamination (BH.6)
Plant Floor Low	7/52-5/55	Design	2000	U234	1.73E-03	5.48E-01	5	Resuspension TBD-6001 Section 8.5.2Residual Contamination (BH.6)
Supervisor	7/52-5/55	Design	2000	U234	1.73E-03	5.48E-01	5	Resuspension TBD-6001 Section 8.5.2Residual Contamination (BH.6)
Clerical	7/52-5/55	Design	2000	U234	0.00E+00	5.48E-01	5	Resuspension TBD-6001 Section 8.5.2Residual Contamination (BH.6)
Plant Floor High	6/55-12/60	Operation	2000	U234	5.11E+03	4.56E+02	5	Scrap Recovery Furnace Operator Calciner post 1952 (TBD-6001)
Plant Floor Low	6/55-12/60	Operation	2000	U234	2.55E+03	2.28E+02	5	50% of Plant Floor High
Supervisor	6/55-12/60	Operation	2000	U234	2.55E+02	4.56E+01	5	25% of Plant Floor High
Clerical	6/55-12/60	Operation	2000	U234	0.00E+00	0.00E+00	5	10% of Supervisor
Plant Floor High	1/61-12/76	Residual	2000	U234	1.73E-03	5.48E-01	5	Table 6.4 TBD-6001
Plant Floor Low	1/61-12/76	Residual	2000	U234	1.73E-03	5.48E-01	5	Table 6.4 TBD-6001
Supervisor	1/61-12/76	Residual	2000	U234	1.73E-03	5.48E-01	5	Table 6.4 TBD-6001
Clerical	1/61-12/76	Residual	2000	U234	0.00E+00	5.48E-01	5	Table 6.4 TBD-6001